Reclamation has a strategic plan to accomplish its mission in accordance with the Government Performance and Results Act. Within the strategic plan, science and research is one of six principles that guide how Reclamation will achieve our strategic, long-term, and annual goals. The goals and strategies below are excerpted from the 2001 Performance Plan and 2000-2005 Strategic Plan. We have quoted them here to tie these to our specific research focus areas.

Reclamation's Goals	*Reclamation's Strategies*
Protect water quality **Remove Colorado River salt**	**"We conduct research on desalinization methods and technology transfer."**
Meet water and power contracts	**"Research related to water and water resource management, watershed modeling, precipitation forecasting, delivery system enhancements, and technology research and development will lead to improvements in water delivery."**
Achieve cost-effective power production	**"Reclamation conducts research and develops technologies related to effective water resource management. Researchers have been applying water operation models to improve the efficiency of Reclamation's water resource projects."**

Chapter 1:
Enhancing Water Supply Technologies

"Discovery consists of seeing what everybody has seen and thinking what nobody has thought." — Albert Szent-Györgyi

Desalination and Water Purification

Creating new water supplies from unconventional sources

People in many coastal cities are crying, like the ancient mariner, "water, water everywhere/ nor any drop to drink." In coastal and arid areas of the desert southwest, growing populations are struggling to find water to meet increasing demands. Desalination and water purification technologies may provide answers by purifying water from such unconventional sources as seawater and inland impaired and brackish water. These promising technologies can:

- Meet increasing demands. Desalination adds a significant tool to water management. Desalination purifies previously unused water sources and allows advanced reuse and recycling of water, including wastewater.
- Provide water where people live. More than 70 percent of the United States' population currently live near water sources that could be desalinated and used. As more people move to coastal areas, ocean desalination is an increasingly useful and cost-effective option.
- Improve water quality. Desalination purifies water to meet the Environmental Protection Agency's Safe Drinking Water Act and Clean Water Act regulations, ensuring public health and protecting our environment.

Continued Reclamation leadership in desalination, reuse, and other water treatment technology has and will provide advancements that:

- Lower costs. Advances in desalination technology have led to lower operating, maintenance, disposal, and energy costs.
- Reduce energy demands. Projects such as solar ponds may even generate energy. Desalinating local surface water sources eliminates the need to pump ground water or move water across basins.
- Reduce environmental impacts and create sustainable projects.
- Demonstrate viability and increase public acceptance.

We hope to continue this research by demonstrating promising technologies and further applying new scientific advances to make desalination an answer to the Nation's need for water. Maybe then we'll have water everywhere and lots of drops to drink.

In FY01, Reclamation submitted a report to the Congress on advances made under the Water Desalination Act of 1996. The Commissioner's transmittal letter said, "We believe these demonstration projects are crucial steps in continuing to improve desalination technologies to the point where cities and industries can use them to effectively increase water supplies."

Kevin Price
(kprice@do.usbr.gov)
<http://www.usbr.gov/water/desal.html>

Working with the water supply and treatment community: Desalination and Water Purification Research and Development Program

Under the Water Desalination Act of 1996, the program has renewed federal research and development to determine the most technologically efficient and cost-effective means to produce usable water from impaired sources. The program has awarded 35 cooperative agreements as well as grants and contracts with various research partners. The program awarded several research and study agreements and two pilot plant agreements in FY01. Some significant findings are:

- Advanced membrane materials and technology. Research into membrane surfaces and fouling helped increase membrane life and reduce chemical cleanings, environmental impacts, and capital and operation and maintenance costs. In addition, a project jointly funded with the Army made strong progress toward the 'Holy Grail' of membrane research—a chlorine-resistant membrane.
- Advanced water pretreatment in several membrane projects. One project used pipes submerged in sand to filter seawater. Another project did an excellent job of using bacteria to treat source water for treatment plants. Both techniques have less impact on the environment than conventional technologies. Larger scale studies are needed to determine the extent of possible cost savings.
- Advanced high-pressure seawater pump. This pump reduces energy consumption over 35 percent compared with similar pumps with conventional energy recovery. This can save a significant amount, as energy consumption and capital costs for energy recovery are about 50 percent of the total water cost.
- An innovative, low-cost system based upon evaporation. Dewvaporation, a humidification/dehumidification process, uses low-cost materials and can be built and opepated using unskilled labor. It uses low-grade heat to produce extremely high-quality water. Capital and operation and maintenance costs are much lower than that of any other desalination system available for rural communities.

These advances, and more, would not have happened without Reclamation's involvement. Mark A. Lichtwardt, P.E., of ARCADIS Geraghty & Miller, Inc., explains, "Without Reclamation's funding and support, development and testing of our cost-effective, wind-powered electrodialysis system would not have been possible. The system is currently being commercialized and will provide safe potable water to remote communities throughout the United States and Mexico."

Reclamation is now recognized as a major clearinghouse for desalination research and technology in the United States as a result of our long desalination research legacy and research conducted under the Water Desalination Act of 1996.

Reclamation shares research results through case studies, workshops, conferences, newsletters, and websites. CD-ROMs contain final program reports and a database of advanced water treatment technology information. See the website at <http://www.usbr.gov/water/desal.html>.

Working within Reclamation: Advanced Water Treatment Program

As the primary federal water management agency in the arid west, Reclamation has many unique needs and projects. The Science and Technology Program's Advanced Water Treatment Research (AWTR) provides in-house experts who keep up to date with the latest state-of-the-art water purification and desalination technology. The program combines research and practical experience to use the best technology available.

While the Desalination and Water Purification Research and Development Program works to solve our Nation's future water needs, this research directly meets Reclamation's current and future needs. In FY00 and FY01, AWTR worked on projects in areas such as advanced water treatment, membrane process development, innovative concepts, mobile water treatment pilot plant projects, technology transfer, and chemical water treatment. Specific projects included developing cost estimating guidelines, treating Rio Grande River waters, and Central Arizona Project water with excess chloride, pursuing innovative solutions for dissolved gas, and developing advanced desalination membranes. These projects help Reclamation meet its complex water demands and deliveries, improve surface and ground water quality, meet Native American and rural community water needs, and more.

AWTR is working on many projects to find innovative and inexpensive solutions for urban and rural areas as well as remote and arid reservations.

- Working with the Dakotas Area Office to determine how to treat water in the most spread out water distribution system in the world, the Mni Wiconi Project. AWTR is optimizing treatment and disinfection processes in a conventional water treatment plant. The plant will supply 13 million gallons of water a day to a rural distribution system of over 4,000 miles of pipeline and 35 storage reservoirs on the Lower Brule, Redbud, and Pine Ridge Indian Reservations in South Dakota.
- Providing army surplus reverse osmosis water purification units to reservations like Fort Kipp, Montana, to provide reliable water supplies. These units also supply 600 gallons per hour for the Kickapoo Tribe along the Rio Grande River in Texas.
- Detecting and removing the source of contamination from Methyl Tertiary-Butyl Ether (MBTE) in ground water at the Hopi Reservation in Arizona. AWTR is finding ways to remove MBTE in the reservation's drinking water.
- Pilot testing reverse osmosis pretreatment alternatives to treat Central Arizona Project water in Marana, Arizona.
- Publishing the *Water Treatment Primer for Communities in Need* to share water treatment technologies for small and Native American communities.

The research program also developed, demonstrated, and deployed solar powered water treatment technologies as an economical alternative water supply for Native American and rural communities that are off power grids and water supply networks. The demonstration has led to delivery systems that provide 1,000 gallons per day of safe drinking water to the Navajo Nation.

Reclamation and the American Water Works Association Research Foundation (AWWARF) co-sponsored a workshop to develop a membrane research roadmap by:

- Developing a strategy to improve effectiveness and applicability of membrane technologies
- Developing databases, lessons learned, decision tools, and other ways to capture the knowledge gained from existing facilities
- Developing design information for large systems
- Finding cost-effective and safe disposal options
- Standardizing methods and permitting criteria

The workshop also identified priority projects. Reclamation and AWWARF are jointly funding the three top priority projects. In 2001, we are working on integrating membrane filtration into existing water treatment systems and developing a low-pressure membrane knowledge base. Reclamation provided $60,000, and AWWARF is providing $190,000 for each project. We are planning to jointly sponsor a third project in FY02.

If Reclamation had not approached AWWARF, this workshop and these projects would not have happened. Reclamation's cost share has shown how important these projects are, accelerating private funding and expanding interests for desalination membranes. The report from the workshop is at <http://www.awwarf.com/research/membrane.htm>.

AWWARF is an international research organization dedicated to advancing the science of water to improve the quality of life. The organization helps the drinking water community work together to underwrite a centralized research effort. Subscribers include 48 consultants and 16 manufacturers, as well as 948 utilities that serve over 175 million people.

Reclamation partnered with the National Research Institute on the FY01 Desalination Research and Development Workshop to develop a national set of priorities. The workshop explored high-priority issues (scientific, technological, economic, environmental, and public policy) that need to be addressed now to speed up installing cost-effective desalination facilities.

Twenty-nine people from six nations participated in the 2000 AWWARF/Reclamation Membrane Workshop to develop a strategy to improve applicability of membrane technologies by drinking water utilities.

Photo courtesy of AWWARF

Measuring flows and improving irrigation efficiency

In the Western United States, we depend on a water storage and delivery infrastructure constructed over the past 150 years to provide water for agriculture, municipal use, industrial needs, power generation, and recreation. The increasing demands placed on the finite supply of water in the West make efficient water management and water use even more important.

One cannot manage a resource that cannot be measured or controlled. The Science and Technology Program has made great strides in developing flow measurement technology, coupled with remotely monitored and operated canal control capabilities. On a project diverting 150,000 acre-feet per year, these simple and affordable technologies could save 30,000 acre-feet per year. If water costs are $150 per acre-foot, savings would be $4.5 million for a single project. Additional advantages include increased operational flexibility, decreased operation efforts, increased crop production, and decreased water quality and salinity impacts. Tests and demonstrations are presently underway at a number of sites, including:

- East Bench Irrigation District near Dillon, Montana
- Several irrigation projects near Yuma, Arizona
- Several projects near Boise and Twin Falls, Idaho
- About 15 projects in central Utah
- Several projects in New Mexico, including the Tucumcari Project and the Navajo Project

Cliff Pugh
(cpugh@do.usbr.gov)
<http://www.usbr.gov/rsmg/warsmp>

Water systems automation

Modern data collection, monitoring, and control systems can greatly increase production and water conservation on Reclamation projects, but the science and application of canal automation technologies needs further development. In partnership with Reclamation's Office of Policy's Water Conservation Field Services Program, we have advanced the science through laboratory developments, field installations, and technology sharing with constituents. During 2000, project personnel used the model canal in Reclamation's Water Resources Research Laboratory to develop new instrumentation and software for canal automation. Laboratory staff presented workshops on Modern Methods in Canal Operation and Control and Irrigation Flow Measurement. A total of 77 students attended, representing 10 irrigation districts, 4 foreign countries, 2 consulting engineering firms, 1 automation equipment manufacturer, 1 municipal water utility, the Colorado Division of Water Resources, the Natural Resources Conservation Service, 3 Reclamation area offices, and the Technical Service Center. The staff also prepared written guidelines on the selection and use of canal automation instrumentation, to be used by internal clients, irrigation districts, and students.

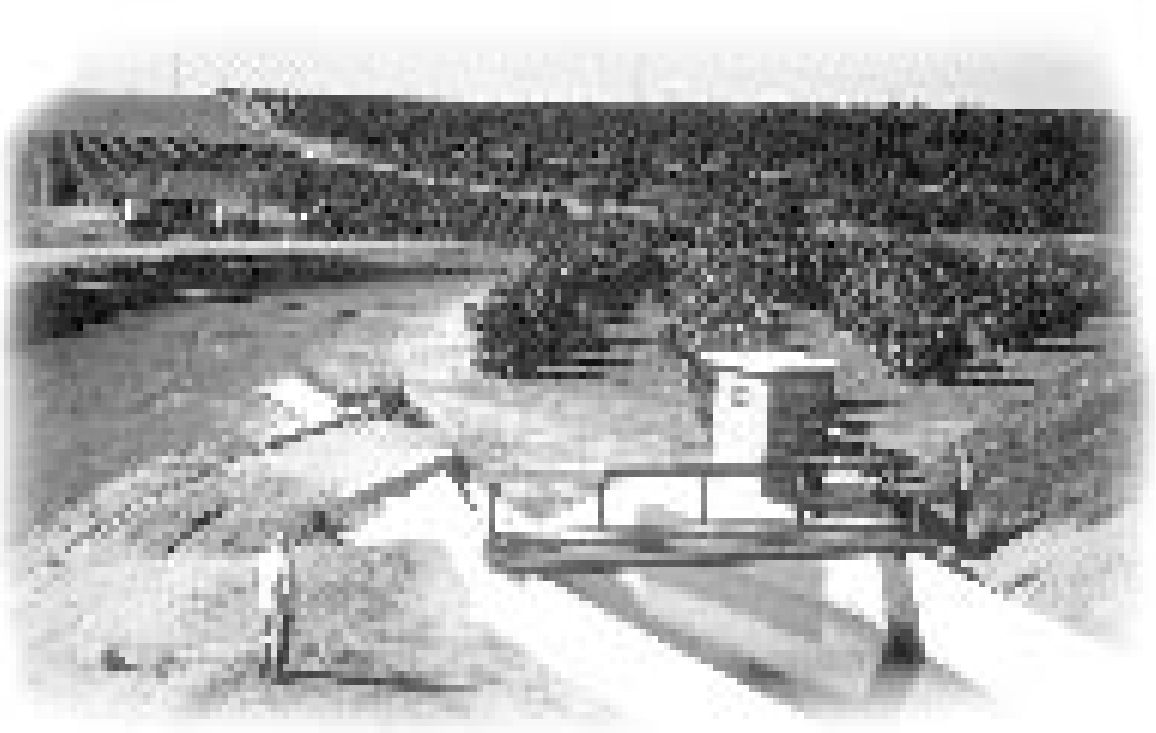
Cliff Pugh explains prototype canal automation system.

Water measurement development and advances

Many flow measurement devices, such as those upstream from a flume or weir, need accurate water level measurements. But water level sensing devices available now are complex and costly. Most of the devices were designed for other industries and are not easily adaptable for irrigation use, which requires a robust, low-cost, and easy-to-use system. Furthermore, many farms Reclamation serves either don't have measurement devices or have ineffective devices which need a lot of maintenance. This project develops, tests, and demonstrates new and existing water level sensors, water-level recording devices, and pipe-flow measurement devices.

In FY00 and FY01, project personnel:

- Developed and demonstrated two low-cost, easy-to-use devices for integrated flow measurement and automatic control of flow rates to farm turnouts and filed patents for these devices.
- Developed a high-frequency, cable-type water level sensor under a cooperative agreement with Utah State University. The device is undergoing further laboratory testing before it can be field tested.
- Tested and reported results for many other devices for both open-channel and pipe-flow applications.



- Tested a variety of water level and gate position sensors, gate actuators, remote terminal units, and data collection, communication, and control software.

- Developed the Automated Farm Turnout and Canal Flow Meter systems. These integrated systems automatically measure flow rates and control deliveries to turnouts. Reclamation has patents pending on these systems. These routines allow gate size, water depth, gate speed, and other factors to vary greatly.

- Began work on a *Flow Measurement Handbook*. This will be a companion to Reclamation's *Water Measurement Manual*, targeted at field users of typical irrigation flow measurement devices.

- Developed (in cooperation with the Agricultural Research Service and the International Institute for Land Reclamation and Improvement) a Windows-based computer program used to design and calibrate flow measurement flumes and weirs.

- Set up three flow measurement demonstration sites.

- Transferred newly developed knowledge and technology to water users at flow measurement workshops in Denver, Colorado; Scottsbluff, Nebraska; and Harlingen, Texas.

- Tested elbow meters for center-point irrigation systems to encourage reliable, low-cost prototype measurement systems.

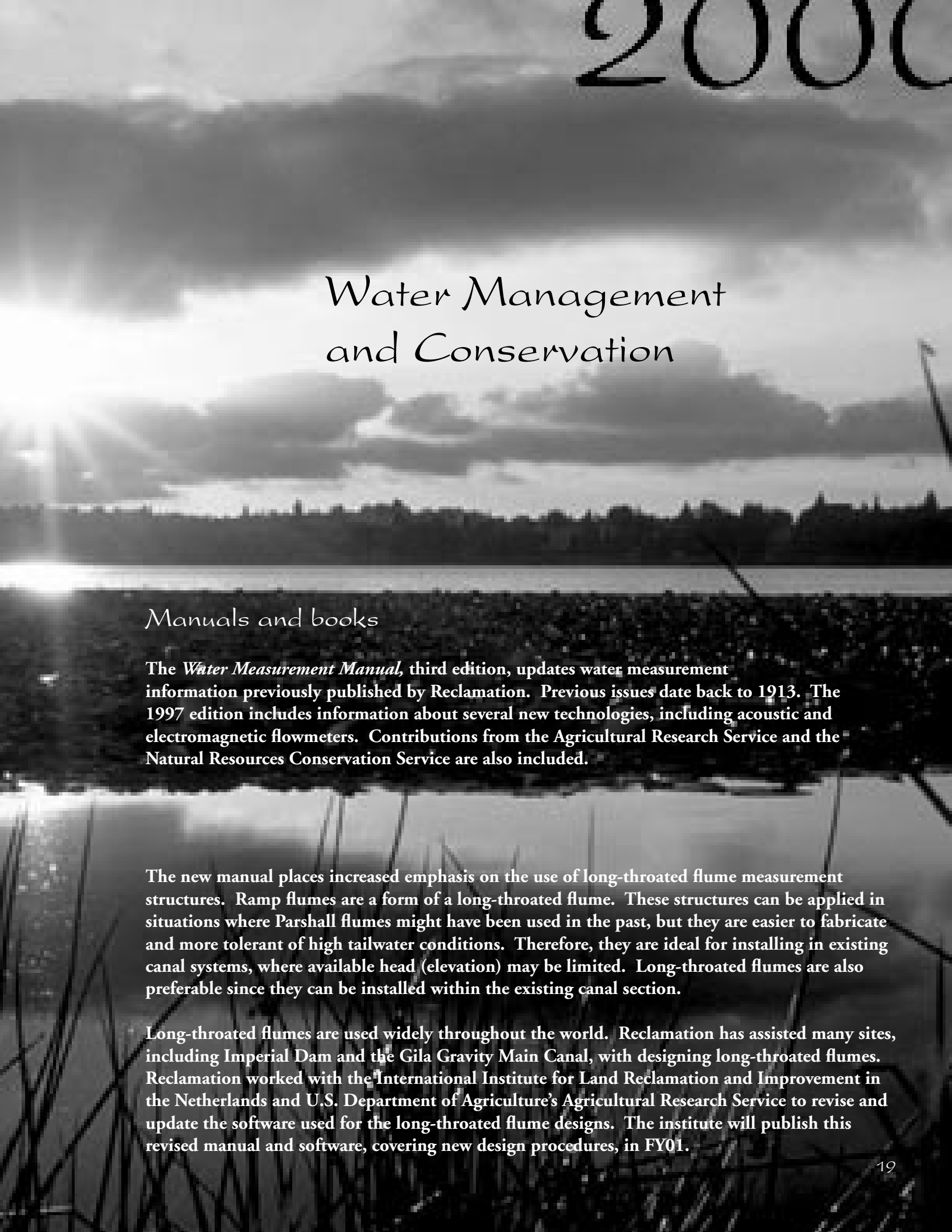
1990

a retrospective

The Science and Technology Program's water systems automation and water systems measurement research has been investigating methods to make water deliveries more efficient than ever before. We are designing and implementing ways to more fully use the canal systems to store and shepherd water and deliver the right amount at the right time to the end user. Here are some highlights of our work with numerous cooperators and partners to more accurately measure and target water deliveries.

Native American

- **Navajo Indian Irrigation Project, Farmington, New Mexico.—Developed supervisory control software for main canal system control. Provided additional documentation and training for Navajo Agricultural Products Industries personnel.**
- **Gila River Indian Community, Sacaton, Arizona.—Provided technical assistance with planning and design of the Pima-Maricopa Irrigation Project, developing design guidelines for the irrigation canal system and reviewing the work of engineering firms performing design work.**
- **Pojoaque Valley Irrigation District, New Mexico.—Designed water measurement structures and instrumentation for data collection and remote monitoring, in conjunction with the Albuquerque Area Office.**
- **Colorado River Indian Tribes.—Improved delivery systems to ensure diversions were within allocation and effectively targeted deliveries.**
- **Pima-Maricopa Irrigation Project, Sacaton, Arizona.—Provided technical expertise to assure that a newly designed, large-scale automation project could take advantage of new technology in water delivery systems.**
- **Nambe, Pojoaque, and San Ildefonso Pueblos and the Pojoaque Valley Irrigation District, New Mexico.—Evaluated water measurement device design recommendations, data recording, and communications equipment.**



Water Management and Conservation

Manuals and books

The *Water Measurement Manual,* third edition, updates water measurement information previously published by Reclamation. Previous issues date back to 1913. The 1997 edition includes information about several new technologies, including acoustic and electromagnetic flowmeters. Contributions from the Agricultural Research Service and the Natural Resources Conservation Service are also included.

The new manual places increased emphasis on the use of long-throated flume measurement structures. Ramp flumes are a form of a long-throated flume. These structures can be applied in situations where Parshall flumes might have been used in the past, but they are easier to fabricate and more tolerant of high tailwater conditions. Therefore, they are ideal for installing in existing canal systems, where available head (elevation) may be limited. Long-throated flumes are also preferable since they can be installed within the existing canal section.

Long-throated flumes are used widely throughout the world. Reclamation has assisted many sites, including Imperial Dam and the Gila Gravity Main Canal, with designing long-throated flumes. Reclamation worked with the International Institute for Land Reclamation and Improvement in the Netherlands and U.S. Department of Agriculture's Agricultural Research Service to revise and update the software used for the long-throated flume designs. The institute will publish this revised manual and software, covering new design procedures, in FY01.

Using our underground water resources effectively

Surface water and ground water are two sides of the same coin. Surface water percolates into aquifers, and ground water seeps back into surface water. Reclamation needs decision support systems that will track both surface and ground water use (called conjunctive use) to help balance how we use water to maintain and improve project yield, protect the environment, and maintain ground water resources at safe levels.

Information from computer models helps facilitate negotiations with stakeholders about how to operate Reclamation facilities and modify water use operations. To facilitate such negotiations, Reclamation's Science and Technology Program is developing a conjunctive use decision support system and plans to demonstrate this system on part of the Friant Unit in California's Central Valley Project. This system will provide a variety of water resources planning information, in real time, from remotely hosted computer models and geospatial databases, including:

- An economically driven water resources planning model
- A crop consumptive use analysis model using satellite imagery to classify crop types, locations, and acreages
- An integrated ground water-surface water model reservoir to quantify the effects of ground water recharge and extraction options
- An ArcIMS based geospatial database system providing access to real time maps, model results, and database information to simulate conjunctive use

With these tools, Reclamation and stakeholders can work together to find the best ways to use surface water and ground water together.

Managing water isn't just on the surface—we need to consider the underground movement. The amount of ground water in storage in the world is more than 30 times greater than all the fresh water lakes and streams. It is a resource that we can't do without. Reclamation's Science and Technology Program is examining these relationships, water quality problems, well production, and other issues vital to managing water in the West.

Rod Tekrony
(rtekrony@do.usbr.gov)
<http://www.usbr.gov/gwd/>

Pipe clogging

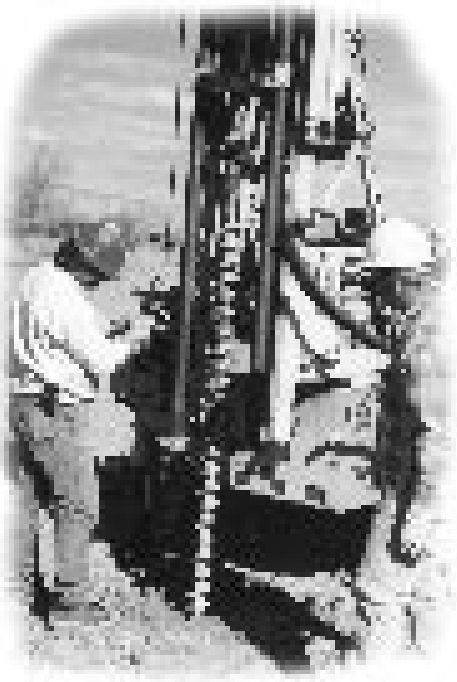
Reclamation has built over 6,000 miles of agricultural drains in the last 50 years. Half of these are corrugated plastic pipes. These plastic agricultural drains are designed so that even if half the openings in the pipe are clogged, the drain will still work. About 15 years ago, Reclamation started to transfer these successful plastic drains to solve other problems, such as draining the water that travels under a dam, away from the toe of the dam.

However, while agricultural drains handle small amounts of water pressure, toe drains on dams may handle much larger amounts. Thus, the percentage of opening in the pipe becomes more critical. For example, at Lake Alice Dam, Nebraska, graded sand envelope material clogged the openings in the drainpipe at the toe drain. This led to undesirable pressure in the dam. The Science and Technology Program is helping to determine whether drain clogging is a more widespread concern. If it is, design changes may be needed to address the problem.

Biofouling in water wells

Wells tap ground water held in aquifers—porous, water bearing rocks underground. These wells also transport oxygen into the aquifer. When bacteria in aquifers are exposed to oxygen, they create a slime which clogs well screens and the aquifer material around the screen. This clogging shortens the life of the well.

The Science and Technology Program is working in Reclamation's Closed Basin Project in Colorado to find ways to clean and rehabilitate the wells and come up with new design criteria to solve this problem before it starts. The program is testing various treatments with heat, chemicals, and flushing for rehabilitation efficiency. The world's water well industry will benefit from this research.



Testing and observation wells help measure our invisible resources.